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ARTIFICIAL NEURAL NETWORK MODELLING FOR IQ CLASSIFICATION BASED ON EEG SIGNALS

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Electroencephalogram (EEG) is a non-invasive approach for measuring brainwaves applied extensively in cognitive studies. Intelligence, which is commonly gauged as intelligence quotient (IQ) is one of the human potential ability that originates from cognitive functioning of the brain. Recent researches have shown that correlation exists between EEG and IQ. Furthermore, various advanced studies on the EEG signal are conducted using advanced computation methods. However, a systematic approach for IQ classification based on brainwaves and intelligent modelling technique has yet to be studied. Hence, this thesis proposed a practical and systematic approach to develop IQ classification model via artificial neural network (ANN) based on EEG sub-band features which then, can be related with brain asymmetry (BA) and learning style (LS). The protocols involved EEG recording during resting with eyes closed and answering the conventional psychometric test. Fifty subjects of UiTM students are divided into three IQ levels based on the IQ scores from Raven's Progressive Matrices as the control group. Power ratio (PR) and spectral centroid (SC) features of Theta, Alpha and Beta are extracted from left prefrontal cortex EEG signals. Then, the distributions of sub-band features are examined for each IQ level. Cross-relational studies are also done between IQ and other cognitive abilities, which are brain asymmetry and learning style based on EEG features. Further, IQ classification models comprising of inputs based on PR and SC features (Model A and Model B) are developed using multilayer feedforward network. Findings from this research showed that sub-band PR and SC features are indeed correlated with IQ. Consequently, the network models yielded low mean squared error (MSE) and fulfilled the correlation requirements in classifying IQ levels. In cross-relational studies, findings have also revealed that PR and SC in relaxed closed-eyes state reflect the relationship between intelligence and other cognitive abilities. The results showed that different balanced states of the brain and learning styles can be mapped to distinct IQ levels using the developed models. Results also demonstrated that high IQ is obtained when subjects maintain relatively balanced hemispheric control. Additionally, results also revealed that medium and high IQ levels are capable of utilising four learning styles compared to low IQ level where only three learning styles were utilised. In conclusion, this research has proven that IQ level classification via EEG and ANN modelling is successful specifically the PR and SC features at resting EEG that can be considered as a stable biological marker in relation to cognitive performance. In addition, the study also confirmed that left hemisphere of the frontal region is adequate for IQ recognition.

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In the name of Allâh, Most Gracious, Most Merciful.

Alhamdulillah, all praise belongs to Allâh, we praise Him, seek His help, and ask for His forgiveness. We seek refuge in God from evils of our souls and our bad deeds. A person, who is guided by God, will never be misguided by anyone and a person who is misguided by God can never be guided by anyone. I bear witness that there is no God but Allâh alone, Who has no partner. That which Allâh wills (will come to pass). There is no power but with Allâh.

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*".... **Allâh is sufficient for me; there is no true god but He**; on **Him do I rely**, **and He is the Lord of the Mighty Throne.**"* (Quran 9:129).

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND

Electroencephalogram (EEG) is a classic non-invasive method that can be considered as inexpensive and convenient measurement technique in assessing physiological changes relating to brain function. Additionally, EEG can be applied under various circumstances as compared to other modalities [1-5] namely functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and regional cerebral blood flow (rCBF) analysis [6-8]. Implementation of EEG includes multidisciplinary research that range from sleep recognition [9] to brain computer interface (BCI) [10]. Furthermore, various advanced studies on EEG signals are integrated with intelligent signal processing (ISP) technique where information obtained from raw signal can be fully extracted with the implementation of advanced processing algorithms and artificial intelligence [11-13]. Among the most widely implemented ISP approaches include expert systems, genetic algorithms (GA), fuzzy logic (FL), and artificial neural network (ANN) [11, 14]. Lately, ANN has established itself as the most success modelling technique in biomedical applications [15-24], particularly in the area of pattern recognition [25]. The primary benefit of ANN classifiers are the ability to learn and generalise the solution for complex problems [26, 27].

Generally, the importance of brain in human development is deeply connected to human potential based on research findings since 1960s [28]. There is a large degree of untapped potential in individuals that would allow human to break barriers and achieve optimal performance [28, 29]. Indeed, brain functioning can be altered and performance can be improved invariably. This leads to endless attempts to use the brain more effectively [28-34]. Thus, with the brain as the source of ability, individual differences in mental performance can be optimised through training, which can also be related with other cognitive abilities [35-39].

Cognitive ability is a subdivision of human potential that refers to individual's characteristic approach in information processing. This is well-established within the